

1N-92-CR

11.17.

12-10

4P

Final Report

NASA Grant NAG5-1323

"Hard X-Ray / Microwave Spectroscopy of Solar Flares"

1 Mar 1990 - 29 Feb 1992

Principal Investigator:

Dale E. Gary
Solar Astronomy 264-33
California Institute of Technology
Pasadena, CA 91125

May 1992

(NASA-CR-194399) HARD X
RAY/MICROWAVE SPECTROSCOPY OF SOLAR
FLARES Final Report, 1 Mar. 1990 -
29 Feb. 1992 (California Inst. of
Tech.) 4 p

N94-13958

Unclas

G3/92 0186010

Final Report

NASA Grant NAG5-1323

"Hard X-Ray / Microwave Spectroscopy of Solar Flares

Introduction

The joint study of hard X-ray and microwave observations of solar flares is extremely important because the two complementary ways of viewing the accelerated electrons yield information that cannot be obtained using hard X-rays or microwaves alone. The microwaves can provide spatial information lacking in the hard X-rays, and the X-ray data can give information on the energy distribution of electrons that remove ambiguities in the radio data. A prerequisite for combining the two data-sets, however, is to first understand which range of microwave frequencies correlate best with the hard X-rays. This SMM Guest Investigator grant enabled us to combine multi-frequency OVRO data with calibrated hard X-ray data to shed light on the relationship between the two emissions. In particular, we investigated the question of which microwave frequencies correspond to which hard X-ray energies, and what is the corresponding energy of the electrons that produce both types of emission.

The original amount awarded for this grant, \$30 K, was supplemented in August 1990 by an additional amount of \$39.5 K to support work by Dr. G. Hurford. The original work was unavoidably delayed while the team at NASA Goddard Space Flight Center corrected a calibration problem with the hard X-ray data. For this reason, at the end of the grant period in February 1991 we requested a no-cost one-year extension.

Results

The work originally proposed has been completed, and is in the process of being written up in a journal article to be submitted to Solar Physics. A preliminary report was presented at the April 1991 meeting of the Solar Physics Division of the American Astronomical Society. Since then, the core of the work has been completed, but a complication has arisen that has slowed publication of the results, as explained below:

A total of 30 solar bursts were jointly observed by the Owens Valley Radio Observatory (OVRO) frequency-agile array and the Hard X-Ray Burst Spectrometer (HXRBS) on SMM during March 1989. A subset of 8 of these

bursts contain relatively simple temporal peaks in both the radio and hard X-rays. We have compared the temporal structure of these peaks in the two regimes as functions of both hard X-ray photon energy and radio frequency. This work requires the unique combination of calibrated SMM hard X-ray spectral data and OVRO radio data at many frequencies. As first noted by Nitta and Kosugi (1986) [Nitta, N., and Kosugi, T. (1986) *Solar Physics* 105, 73.], we find that the hard X-ray count rate and the optically thin radio flux vary at the same rate only for relatively low X-ray photon energies (60-100 keV). In addition, we find this is equally true for any optically thin radio frequency, but not for optically thick radio frequencies. The Nitta and Kosugi interpretation is cast into doubt, however, when hard X-ray spectra are used for which the instrumental response is taken into account (deconvolved). Since the raw count rates can be severely affected by lower energy photons, especially for steep spectra, we believe our approach to be more accurate. When deconvolved spectra are used, the X-ray photon flux and optically thin radio flux vary at the same rate for even lower X-ray photon energies than found by Nitta and Kosugi, which leads us to conclude that the original premise of Nitta and Kosugi is wrong. That is, the rate of variation of hard X-ray fluence and radio flux cannot be used to uniquely identify the energy of the electrons giving rise to the radio emission.

We initially thought that the problem could be resolved by considering the radio emission to be generated by a population of trapped electrons, which are physically distinct from the X-ray generating electrons. However, looking into the evidence from the OVRO interferometry data, which give information on the source size at each frequency, we find that trapping may be a smaller effect than we at first anticipated. In particular, although trapping does occur, it cannot explain quantitatively the discrepancy in slope that we find. Working on this problem has delayed publication of our results, and it now appears that we will have to publish one paper reporting the discrepancy, which we can do immediately, then another paper, after further investigation of the interferometry data, that attempts to account for the discrepancy.

The additional work by Dr. Hurford involves a burst observed simultaneously with three antennas at OVRO and with HXRBS on SMM, on 1988 July 18. Preliminary work was been presented at the American Astronomical Society meeting in January 1991, and also appears in the proceedings on the Symposium on Nobeyama Radioheliograph, held in November 1990. Preliminary findings are as follows:

The radio burst showed considerable variation in size with frequency, but after measuring the size (in one dimension) with three antennas of the

OVRO Solar Array this variation could be taken into account. The resulting brightness temperature spectrum could be fit with a nonthermal gyrosynchrotron spectrum, with a high-frequency slope that agrees well with the electron energy distribution deduced from the hard X-ray data from HXRBS. We are now investigating the source size variations as a function of frequency to measure how the magnetic field strength and number density of nonthermal electrons vary with distance across the inhomogeneous source. If the variation is due entirely to the number density of accelerated electrons, the spatial distribution of the number density is shallower than an exponential, but steeper than a gaussian.

Abstracts and Papers

Hurford, G.J. and Gary, D.E. (1991), "The effects of source inhomogeneity on solar microwave bursts," BAAS 23, 1066.

Hurford, G.J., Gary, D.E., and Bromley, J.W. (1990) "Microwave and hard X-ray diagnostics of nonthermal electrons in a solar burst," Proceedings of the Symposium on Nobeyama Radioheliograph, Nobeyama Radio Observatory, p. 244.

Gary, D.E. and Hurford, G.J. (1991) "Joint microwave/hard X-ray observations of solar bursts during March 1989," BAAS 23, 1066.

Gary, D.E. and Hurford, G.J. (1992) "Typical energy of microwave-emitting electrons in solar flares deduced from joint hard X-ray/microwave observations," to be submitted to Solar Physics.